Spring 2005

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Features work by Leslie Duram, Tomasz Wiltowski, Satya Harpalani, Y. Paul Chugh, Bane Kroeger, Manoj Mohanty, Stewart Wessel, and other researchers; special coal-related cover story.

PERSPECTIVES

SPRING 2005

RESEARCH AND CREATIVE ACTIVITIES

SOUTHERN ILLINOIS UNIVERSITY CARBONDALE

A Second Act for Illinois Coal?

ALSO: RHYTHM IN THE GRAIN ✠ FOOD FOR THOUGHT ✠ NAVIGATING THE BRAIN

OutLook

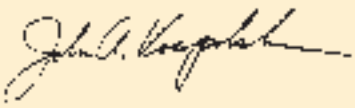
Coal-related projects at SIUC are a perfect example of research that hits close to home but has worldwide implications.

Many Illinoisans have lost their jobs since stricter Clean Air standards prompted many power plants to stop buying high-sulfur Illinois coal. SIUC's Coal Research Center has long sought to combat this economic trend by reducing the sulfur dioxide and other pollutants that are byproducts of coal burning. As our cover story shows, new coal gasification systems can solve the sulfur problem once and for all—and help put the brakes on global warming too.

Coal gasification is no pipe dream. It has a long history, and technologies are being fine-tuned to make it a nonpolluting way to generate electricity, produce hydrogen for fuel cells, and reduce carbon dioxide emissions. Some of SIUC's clean-coal researchers have been working in these areas. The work of researchers here also has improved mining productivity and reduced waste—efficiency gains that can tip the balance sheet in favor of gasification plants.

SIUC's research shows that promoting Illinois coal, moving toward greater energy independence, and reducing the environmental toll from fossil fuels are compatible goals. Our track record in coal R&D poises us to do much more, and we are moving aggressively to expand our role in energy research over the next decade.

Coal can be part of the energy problem—or, through the development of ultra-clean technologies that allow it to substitute for natural gas and petroleum, it can be part of the energy solution. We plan to make sure it's part of the solution.



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For information about the research program at SIUC, visit www.siu.edu/~ovcr, or contact John A. Koropchak, Vice Chancellor for Research and Graduate Dean, (618) 453-4551, koropcha@siu.edu, or Prudence M. Rice, Director, Office of Research Development and Administration, (618) 453-4531, pmrice@siu.edu.

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Cover: "And Our Fathers Before Us": Mike Darnell waits for his shift at the Zeigler no. 11 mine in Coulterville, Illinois, March 2004. The image is by Lee Buchsbaum, an MFA candidate in photography who has documented the faces of coal mining in Southern Illinois. See more of his work at www.lmbphotography.com.

PERSPECTIVES
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RESEARCH AND CREATIVE ACTIVITIES
SOUTHERN ILLINOIS UNIVERSITY CARBONDALE

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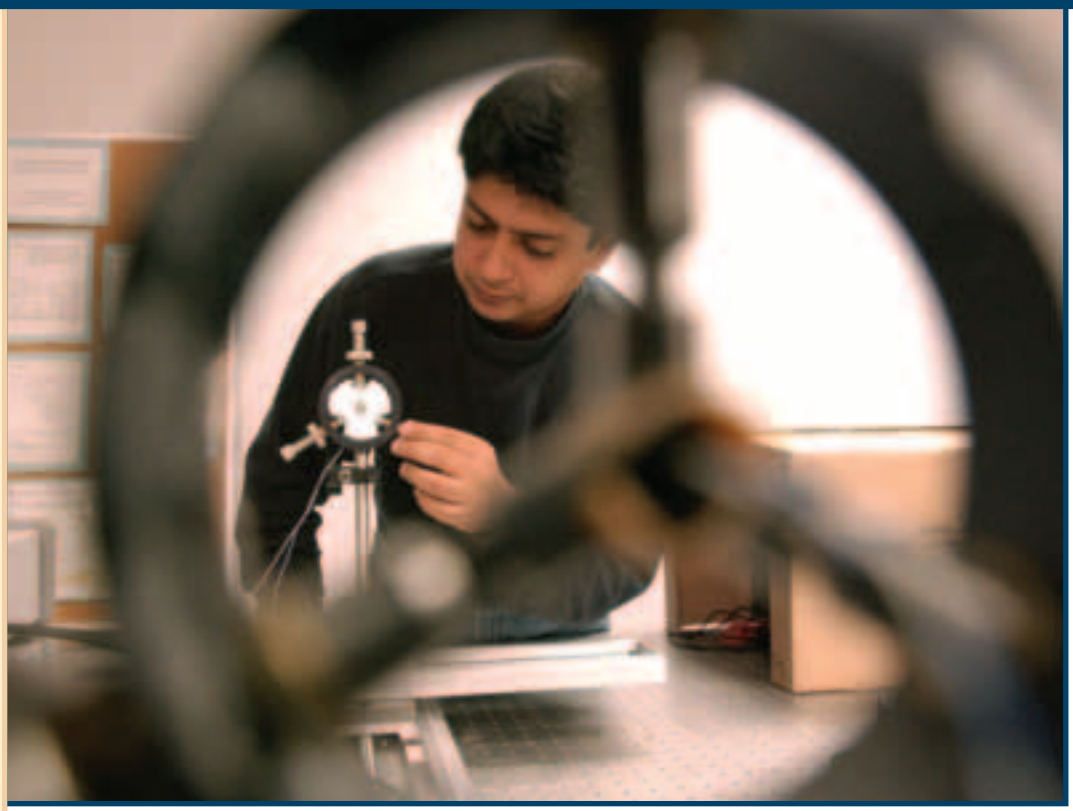
A SECOND ACT FOR ILLINOIS COAL?

Coal gasification may be our best near-term bet for affordable, clean energy. It offers a way to reduce the greenhouse gas emissions that are fueling global warming. It offers a way to produce hydrogen for fuel cells. And by removing pollutants at the front end of the process, it offers a way for high-sulfur Illinois coal to compete successfully with low-sulfur but lower-Btu western coal.

Can gasification fulfill these promises in an economically feasible way? Faculty and students here are working on all aspects of this technology, as well as finding cost savings by improving mining productivity.



Ajay Mahajan demonstrates an ultrasonic-based locational system intended to improve brain surgery.

NAVIGATING THE BRAIN

A GPS-like system being developed at SIUC could help surgeons navigate through the brain to find and remove everything from tumors to bullet fragments easily, cheaply, and with hardly any "cutting" at all.

"This is a project I believe could save lives," says mechanical engineering professor Ajay Mahajan of an ultrasonic-based locational system he designed with former Carbondale neurosurgeon Sumeer Lal. SIUC has filed a patent application on the invention.

Neuro-navigation is nothing new. More than a decade ago, surgeons began harnessing computers to cameras to create high-tech guides that could help them "see" what they were doing in the brain. Such precision allows them to make smaller incisions and remove only what needs to go, cutting the risk of complications and speeding healing.

But these vision-based systems are pricey and hard to maintain. The cameras take up a lot of space, and if someone moves into their sightlines or, worse, bumps them, they can lose track of where they are or shut down altogether.

"When they stop working, calibrating them again is very difficult," Mahajan says. "It only takes about five to 10 minutes, but you have the patient's head open at that point. Everything is covered in surgical drapes, so the fiducials (small markers, attached to the patient's head, that serve as preoperative calibration aids) are no longer accessible."

Mahajan's system, adapted from one he developed some years ago at Tulane University to track robots, gets rid of the cameras. It replaces them with a head restraint from which ultrasonic sensors branch off like tree limbs and adds a couple of sensors to the surgeon's probe. The two sensors on the probe act as transmitters while those on the head restraint serve as receivers, allowing the equipment to map the probe's movement through the brain in three dimensions.

"This is very much like a GPS system, except that it's indoors, and instead of satellites, we have ultrasonic receivers," Mahajan says.

Because the receivers that replace the cameras take up so much less space, sightline problems don't occur. And because they remain in place—not on the patient's head but close by—recalibration in a sterile environment is a snap.

The new system is even more accurate than the old. "In the past couple of months we've gotten it down to sub-millimeter accuracy, which is better than the old system," Mahajan says. The improved precision should make the system even more attractive to neurosurgeons.

Hospitals can pay as much as $500,000 to $750,000 for standard image-guided neurosurgery equipment. Mahajan estimates that the cost of the new system would be significantly less—perhaps in the neighborhood of $50,000 to $75,000.

It will take some time before the system shows up in operating rooms. Although the finished product will work exactly the way Mahajan's experimental set-up does, it will look different.

"This project is still in its infancy—we don't even have a prototype yet," Mahajan says. "But there has been a considerable amount of interest, and as the word has gotten out, we are having companies call us about it. A big company would have the resources to develop and package it. We've shown it has a definite application; we'll let somebody else take it from there."

For more information, contact Ajay Mahajan, mahajan@engr.siu.edu or 618-453-7007.

—K. C. Jaehnig

HEADING EAST?

Like most young outdoorsmen, he seems to be seeking the simple things in life: a quiet, out-of-the-way place to call home, great deer-hunting grounds, and a soul mate with whom to start a family. No wonder he's looking in the agricultural Midwest, what with its remaining forests and abundant venison. But he's not your average kind of guy—he's a cougar.

"There have been 21 confirmed cougars in nine Midwestern states and one Canadian province in the past 18 months. In the 10 years before that, we had one or two a year," says Clayton Nielsen, a wildlife ecologist with SIUC's Cooperative Wildlife Research Laboratory and director of scientific research for the Cougar Network. This nonprofit research group tracks "hard evidence" of cougar movements and networks with federal, state, and other wildlife agencies.

"The phenomenon of cougars showing up in the Midwest is a relatively new one. It's the acceleration that's got people really interested right now," Nielsen says.

In some cases, the cougars being found in the Midwest may be released pets, Nielsen says. But migration seems to be responsible for some incidences. Nielsen and the Cougar Network are tracking scientifically confirmed cougar appearances on a "big-picture map" that's yielding a comprehensive view of the cats' movements outside their contemporary ranges.

Mere sightings don't count. Carcasses, cougar DNA, and verifiable photos provide the most credible evidence to date of cougars' eastward migration, Nielsen says.

"From a research perspective, we want to know where the movement corridors are, how the cougars are getting here—and if they do [get here in greater numbers], we'd like to know if there's enough habitat for them to survive and to eventually re-colonize," he says.

One thing's for sure: These cats will brave the water. Those showing up in the Midwest must first swim the Mississippi River.

Cougars, also known as mountain lions, panthers, or pumas, were extirpated from the eastern half of the United States—with the exception of Florida—about 150 years ago. Today, our continent's biggest cats usually occupy secluded tracts of land out West.

But rising cougar populations and habitat loss there appear to be major factors in the felines' recent forays east, says Nielsen.

A couple of cougars have turned up dead in Southern Illinois since summer 2000. One of those "was a relatively young male, four to six years old, who'd recently eaten a fawn and appeared to be a wild animal," says Nielsen, who was present at the cat's necropsy, conducted at the Wildlife Lab.

However, he says, "There are no breeding populations of cougars in the Midwest. So the cougars coming here aren't going to find one of the things they're most interested in, and that's mates."

In their travels, they continue seeking suitable partners until they're either killed by hunters, hit by cars or trains, or perhaps decide to turn around and head back home. So it remains uncertain whether cougars can reestablish themselves outside the West.

"There's no fear we're going to be overrun anytime soon," Nielsen says, "but I do think this is a naturally occurring phenomenon. As scientists, we'd like to help people plan for their possible arrival and to figure out whether or not we can co-exist."

Nielsen, a veteran at tracking wild cats, also has studied the bobcat's comeback in Illinois.

For more information, contact Clayton Nielsen, kezo92@siu.edu or 618-453-6930.

—Paula Davenport

Joel Rissman on his certified-organic grain and livestock farm in northern Illinois. *Photo by Leslie Duram.*

FOOD FOR THOUGHT

Want to be a rebel with a cause? Buy organic. Better yet, buy locally grown organic.

That's the advice of organic-foods advocate Leslie Duram, chair and associate professor of geography and environmental resources at SIUC. A Kansas native, she grew up hearing about farm buyouts and farmers' disillusionment with conventional agriculture. Since the early 1990s she's been investigating the organic farming movement as a possible solution to those economic woes

Several years ago *Perspectives* reported on a survey Duram did of organic farmers in Illinois. Her new book, *Good Growing: Why Organic Farming Works* (University of Nebraska Press), is a comprehensive work geared to general readers as well as academics.

Duram's countless conversations with family farmers have led her to conclude that organic farming is the only viable way for small- to medium-sized family farms to thrive in the United States. To make that point, her book quotes extensively from five farmers across the country that she's been visiting and interviewing for more than a decade. This technique allows the farmers to talk directly to the reader, as it were, about their experiences and concerns.

Their certified-organic enterprises are diverse: a 500-acre vegetable and sheep farm in upstate New York; a 14-acre citrus grove in Florida that has been organic since the 1940s; a 300-acre livestock, soybean, and grain farm in northern Illinois; a 5,700-acre grain farm on the high plains of eastern Colorado; and a 250-acre vegetable farm in central California. Despite their differences, the five operations are doing very well, Duram says.

These farmers have learned to focus more on profit margins than on yields. Although yields tend to be lower with organic farms, there also are lower input costs, since the farmer isn't spending money on pesticides, herbicides, or synthetic fertilizer. Plus, many organic foods are marketed directly to the consumer, cutting out the middleman, and many carry a premium price.

Thus profits can sometimes be higher than on conventional farms. Joel Rissman, who raises cattle, chickens, soybeans, and grain on 300 acres in Illinois, says he has a goal of realizing as much income with his certified-organic farm as his neighbors do with a 1,000-acre conventional spread—and he thinks this will be attainable.

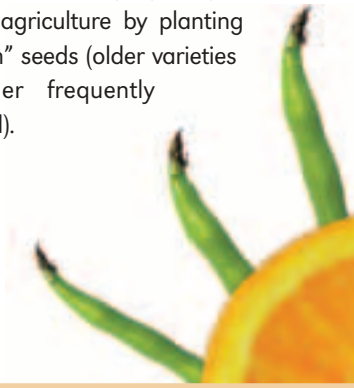
Duram used her interviews to identify what qualities are needed to be successful at organic farming and what issues are of most importance to organic farmers. These farmers have many things in common, she has found.

They're independent enough not to care what their neighbors say about their "strange" farming techniques. They're frugal, fixing and even making some of their own equipment. They emphasize diversity in crops, which gives them the flexibility to compensate for the lack of chemical control of insects and weeds.

They're entrepreneurial in trying different marketing techniques, especially direct marketing to consumers. Finally, they'll do whatever it takes to get the information they need, and they run on-farm experiments to see what works best for a given crop.

As Naioma Benson, co-owner of the organic grain farm in Colorado, says: "Organic farmers are innovators. If America loses family farmers, they've lost innovation."

Duram notes a range of ecological benefits that organic farms provide to society: improving soil resources, reducing the amount of agrichemicals entering water supplies, and diversifying the gene pool for agriculture by planting "heirloom" seeds (older varieties no longer frequently cultivated).



Building soil quality and a healthy farm ecosystem is a top goal for all of these farmers. That involves techniques like using a rotation schedule of three or four crops in one field; using beneficial predator insects to help control pests; using "green" manure (vegetation grown to be plowed under, providing nitrogen and other nutrients) to build soil fertility; and getting the proper balance of microbes in the soil. It may also mean soil-conservation measures such as planting trees in areas bordering streams, to reduce runoff.

In her book Duram reviews information from more than 300 published studies, done both in the United States and abroad, on the sustainability, economics, and nutritional advantages of organic farming. But she is as interested in the social aspects of organic farming as the strictly agricultural ones.

Organic farms, especially those that market locally, strengthen communities, she says. They offer a way for small- and medium-sized family farms to stay in business, countering the trend toward farm buyouts, corporate agriculture, and dwindling rural populations.

Duram suggests a number of policies that the federal government could adopt that would help organic producers. They include providing technical assistance (little is now geared to organic production), paying farmers for the conservation improvements they make on their farms, and providing subsidies to help farmers through the three-year transition period from conventional to organic farming. (To be certified organic, fields must be free of synthetic chemicals for three years running.)

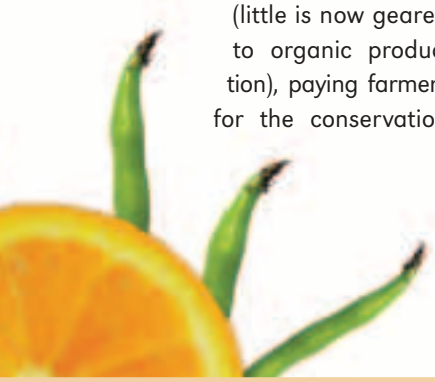
Organic products are growing in popularity, and organic farming, Duram says, is "becoming mainstream—for better and for worse." The trend toward organic production by large corporate farms is good from an environmental point of view but doesn't offer the same kinds of benefits to local communities that family-owned farms do, she says. She encourages consumers to know where their food comes from and buy locally.

Or, to give the last words to Terence Welch, a marketing manager hired by the California farm: "I always tell people: the most revolutionary act you can commit is to go to a farmers' market and buy from an organic grower. Because then you have bypassed the whole distribution system.

"You're buying food that's local, so you're supporting your community; you're supporting an agriculture that's benefiting the earth."

For more information, contact Leslie Duram, duram@siu.edu or 618-453-6084.

—Marilyn Davis



RESEARCH SURVEY

Changes in how Illinois courts handle juvenile cases may result from recent research at the SIU Law School.

Surveys of how the juvenile court system functions in the First and Second Judicial Circuits revealed a need for greater communication and a more collaborative, less adversarial approach among those involved in juvenile cases, according to Mary Rudasill, clinic director and associate professor at the law school.

"Better decisions might be made for the family and for the children if more information is shared prior to the court proceedings," she says. "There is seldom a meeting of the agency people and the prosecutor and the public defender, even though the purpose of the Juvenile Court Act is to help the family and help the kids."

As a part of the research, project coordinator November Davison sent surveys to judges, prosecutors, public defenders, and Illinois Department of Children and Family Services personnel who handle juvenile and neglect cases within the two judicial circuits, which comprise 21 counties in southern and southeastern Illinois. George Vineyard, of SIUC's Center for Basic Skills, compiled the survey results.

The responses noted a desire for more training regarding the Illinois Juvenile Court Act, training for attorneys and judges on DCFS policies, more meetings between attorneys and caseworkers before adjudicatory hearings, and judges permanently assigned to juvenile court on a circuit basis.

The latter suggestion has already been presented to an Illinois Supreme Court study committee on juvenile justice. Unlike other court cases, juvenile cases involving abuse and neglect have components of criminal and civil law. They also are lengthy affairs, with disposition hearings and follow-up reviews. The survey indicated a need for judges who not only are well educated about juvenile law and agency services, but who can devote the time necessary to become more familiar with individual cases.

The SIU Law School received a grant from the Administrative Office of Illinois Courts to conduct the research and host an interdisciplinary, two-day training conference on the juvenile court system last year.

—Pete Rosenbery

▲ Kelly DeGrandchamp with a (smallish) silver carp.

RENEGADES

Kelly DeGrandchamp is tracking some mighty big fish. They don't belong in the Midwest, but they're here to stay—so wildlife managers need to learn what they can about these invasives to keep them under control.

They're Asian carp, which grow up to 100 pounds. They come as two kinds, the bighead carp and the silver carp. Both species escaped from southern fish farms during floods and have been making their way north up the Mississippi, Ohio, and Illinois rivers. The Army Corps of Engineers is taking expensive measures to keep the carp from getting a foothold in the Great Lakes, but that may be a losing battle.

These fish pose a big menace to ecosystems because they eat huge quantities of phytoplankton, the invertebrates that fuel small fish. And with small fish edged out of the competition for food, larger predator fish such as lake trout also decline in numbers.

For her master's thesis in zoology, DeGrandchamp has been tracking bighead and silver carp in an 80-mile stretch of the lower Illinois River and one of its backwaters. She's getting a picture of their movements, especially during spawning season, and seeing what habitats they favor over the course of the year.

The information she gleans will give wildlife managers more ammunition to control these invasive species by revealing where the Asian carp are competing with native fish for food. The Army Corps of Engineers, U.S. Fish and Wildlife Service, and Illinois Department of Natural Resources are supporting DeGrandchamp's work, done with guidance from zoology professor James Garvey and SIUC's Fisheries Center.

For more information, contact Kelly DeGrandchamp, kdegrand@siu.edu or 618-453-6091.

—Marilyn Davis

GMOs AND SAFETY

Are GMOs—genetically modified organisms—safe for human consumption? A recent SIUC study suggests that the answer is yes, at least for one type of transgenic corn.

The corn, developed by SIUC plant scientists, includes a bacterial gene that allows it to use nitrogen fertilizer more efficiently. Bits of the foreign gene, or transgene, were detected in the stomach contents of 50 of 56 piglets fed the corn, but were found in only one of the samples taken from the small intestine.

This suggests that the additional gene generally does not survive the digestive process. And no traces of the transgene were found in the piglets' feces, flesh, or blood.

"It seems like it degrades rapidly," says swine expert Gary Apgar, an associate professor of animal science. "We found no evidence that it is absorbed (into the animal), and the risk of its coming out in the environment in the form of waste is nonexistent because we failed to find the gene in either the colon or the feces."

▲ Gary Apgar is investigating the fate of DNA from transgenic corn fed to pigs.

The SIUC study, conducted with the help of Janet Beagle, now a doctoral student at Purdue University, is part of an overall look at GMOs as a component of swine diets. The Illinois Council for Food and Agricultural Research and the Illinois Corn Marketing Board have funded the research.

More than a third of the corn crop in the United States now consists of GMOs. Worldwide, acreage planted in GMO crops is "increasing exponentially," Apgar says, "but there's very limited data on what happens 'downstream.'

"We're taking a total systems approach, looking at every aspect of a single animal—meat, fecal material, blood, digesta [stomach and intestinal contents]—at different ages."

Apgar believes the single trace of transgenic DNA found in the small intestine is not of significant concern. "Until we can better characterize the degradation of dietary DNA, we might be a little cautious," he says. But he thinks the weight of scientific evidence, from other studies as well as this one, supports the idea that GMOs are safe for consumption.

For more information, contact Gary Apgar, pigguy@siu.edu or 618-453-1765.

—K. C. Jaehnig

JOURNEYS IN TIME

"In the year 1503, on the Feast of the Epiphany, an anonymous woman completed a *Book of Sisters,* an account of the lives of sixty-six nuns of the cloister of St. Agnes at Emmerich on the Rhine....Her book reached few readers and was all but forgotten for the next five hundred years....This kind of literary-historical obscurity is more the rule than the exception for works by monastic women of the late Middle Ages. It has led to the mistaken assumption that they left no substantial written records about themselves. But, in fact, they did....The female monastics who produced these works represented a significant presence in medieval society....The task now is to rewrite [the past] with...firsthand accounts from the women whose own histories and works...have long been gathering dust in the archives."

—Anne Winston-Allen, Dept. of Foreign Languages and Literatures, in ***Convent Chronicles: Women Writing About Women and Reform in the Late Middle Ages*** *(Pennsylvania State Univ. Press, 2004)*

"For generations people in this town have been talking and writing about the past. Genealogist, antiquarian, craftsperson, preservationist, historian, storyteller—all have been working to keep connection with the past....This book attempts to recover and attend to all these voices no matter how faintly some may be heard....The pastkeepers of Deerfield have something to teach, principally because they have been working in a small place....Deerfield is a good place to begin to understand how we seek to ground ourselves in time." (*Ed.— Deerfield was the site of a famous French-and-Indian raid in 1704 that killed 45 citizens and took more than 100 others captive.)*

—Michael Batinski, Dept. of History, in ***Pastkeepers in a Small Place: Five Centuries in Deerfield, Massachusetts*** *(Univ. of Massachusetts Press, 2004)*

"The political organization of the Classic period (A.D. 179-948) lowland Maya civilization of northern Guatemala, Belize, and the Yucátan peninsula of Mexico has defied explication....[But historical sources and Classic inscriptions suggest] that Maya political organization was structured by the short-term and long-term...cycles recorded in their calendars, particularly recurring intervals of approximately twenty years (the *k'atun*) and 256 years (the *may*). Maya calendrical science, in other words, was not only a system of precise and predictive astronomical calculations and record keeping but also the foundation or 'deep structure' of their political science. The key is deceptively simple: the Maya are 'the people of the cycle, the people of the may.'"

—Prudence M. Rice, Dept. of Anthropology, in ***Maya Political Science: Time, Astronomy, and the Cosmos*** *(Univ. of Texas Press, 2004)*

BETTER REFUGE

Social workers assisting more than a quarter million Palestinian refugees in the Middle East have an ally in Hussein Soliman.

Soliman, a professor in SIUC's School of Social Work, developed a two-year program to upgrade the skills of about 320 social workers affiliated with the United Nations Relief & Works Agency for Palestinian Refugees in the Near East. The program's goal is to have better-trained professional social workers providing improved services to individuals, families, groups, organizations, and communities.

The program, which is being taught in Arabic, consists of eight courses. Last December and January, Soliman spent nearly six weeks with another professor teaching the first two courses to social workers in Amman, Jordan; Damascus, Syria; and Beirut, Lebanon. Social workers in the West Bank and Gaza Strip will participate for the first time this summer.

The international collaboration between SIUC and the United Nations is unique, according to Beth Kuttab, the director of the Relief and Social Services Department at the Amman headquarters of the U.N. agency.

Kuttab eagerly took Soliman up on his offer last summer to assist her group.

"The social workers comprise about 40 percent of the staff, and are the agency's key link with the most vulnerable segment of the refugee population," she says.

"Better-qualified social workers will enable us to provide higher-quality services to refugees who are the most needy and have no other sources, or insufficient sources, of social safety net assistance."

Most of the social workers are Palestinians who have caseloads of about 250 refugee families apiece. The majority of these staff members have a degree in sociology or the social sciences, but lack specific training in social work skills and methodologies.

The training that Soliman designed includes group interaction and role-playing—quite a contrast to the straight lectures and memorization most commonly used in the Middle East, he says.

Soliman, who has citizenship in both Egypt and the United States, spent summer 2004 conducting a needs assessment and meeting with social workers and refugee families in Jordan, Lebanon, Syria, the West Bank, and the Gaza Strip.

That established credibility with the staff: Soliman did not design the eight courses for the training program until he had an in-depth understanding of the kind of training the social workers needed.

Soliman has selected six international faculty members to teach the courses during the summer and winter breaks over the next two years. The program, Kuttab says, will "really revolutionize our entire approach to social work/social services."

For more information, contact Hussein Soliman, soliman@siu.edu or 618-453-2243.

—Pete Rosenbery

▲ **Hussein Soliman has developed a two-year training program for United Nations-based social workers helping Palestinian refugees in the Middle East.**

CHILD WELFARE

Children referred to the Illinois Department of Children and Family Services (DCFS) will receive a more comprehensive and timely assessment of their living situations thanks to a new program involving the SIUC School of Social Work.

Under the Illinois Model of Integrated Assessment Program, the school is providing expanded mental health and behavioral health services in all but the 18 northernmost counties in Illinois. (Four other institutions are providing services in those counties.)

A $2.93 million DCFS grant has enabled SIUC to hire child welfare specialists, licensed social workers, clinical psychologists, and other personnel to work with 55 DCFS field offices in 84 downstate Illinois counties. The project also will involve research to determine the best ways to meet the needs of the region and state.

The project is a collaborative effort with DCFS child welfare workers, says Mizanur Miah, professor and director of the School of Social Work and the grant's lead investigator. Working closely with DCFS caseworkers, the clinical screeners in the integrated assessment program collect critical family information in the early stage of cases—within the first 45 days after a child enters DCFS care.

The assessments allow DCFS to identify safety risks quickly, improve case planning, and make certain that appropriate services are put in place for the family. Without early assessment, Miah

says, "emotional, behavioral, and mental health needs may go undetected for months." Foster parents will also benefit from early identification of the needs of children they are caring for.

Assessments, which take place in the family home when possible, include in-depth interviews with the children and family members, including birth parents, caregivers, partners, and other significant adults in the child's life. Children from birth to 5 years old receive developmental screenings; children between 6 and 18 years old receive behavioral and mental health screenings.

The assessment program provides for a standardized, uniform check-and-balance system. A child who lives in Cairo and one who lives in Chicago should each have the "same thorough assessment, services should be identified, and children and families should be given the specific services needed," says program director Shari Selander. The program will help DCFS and SIUC determine what services may be lacking in particular geographical areas.

Selander notes that the statewide implementation of the program follows an effective two-year pilot program in the Chicago area.

"This can pave the way for how child welfare operates nationwide. Clearly the eyes of the other states are going to be on Illinois to see how this works."

For more information, contact Shari Selander, sharis@siu.edu or 618-453-7258.

—Pete Rosenbery

KUDOS

• Microbiologist **Kelly Bender** (left) won the 2004 SIUC Outstanding Dissertation Award for work that will aid in the cleanup of a widespread environmental contaminant.

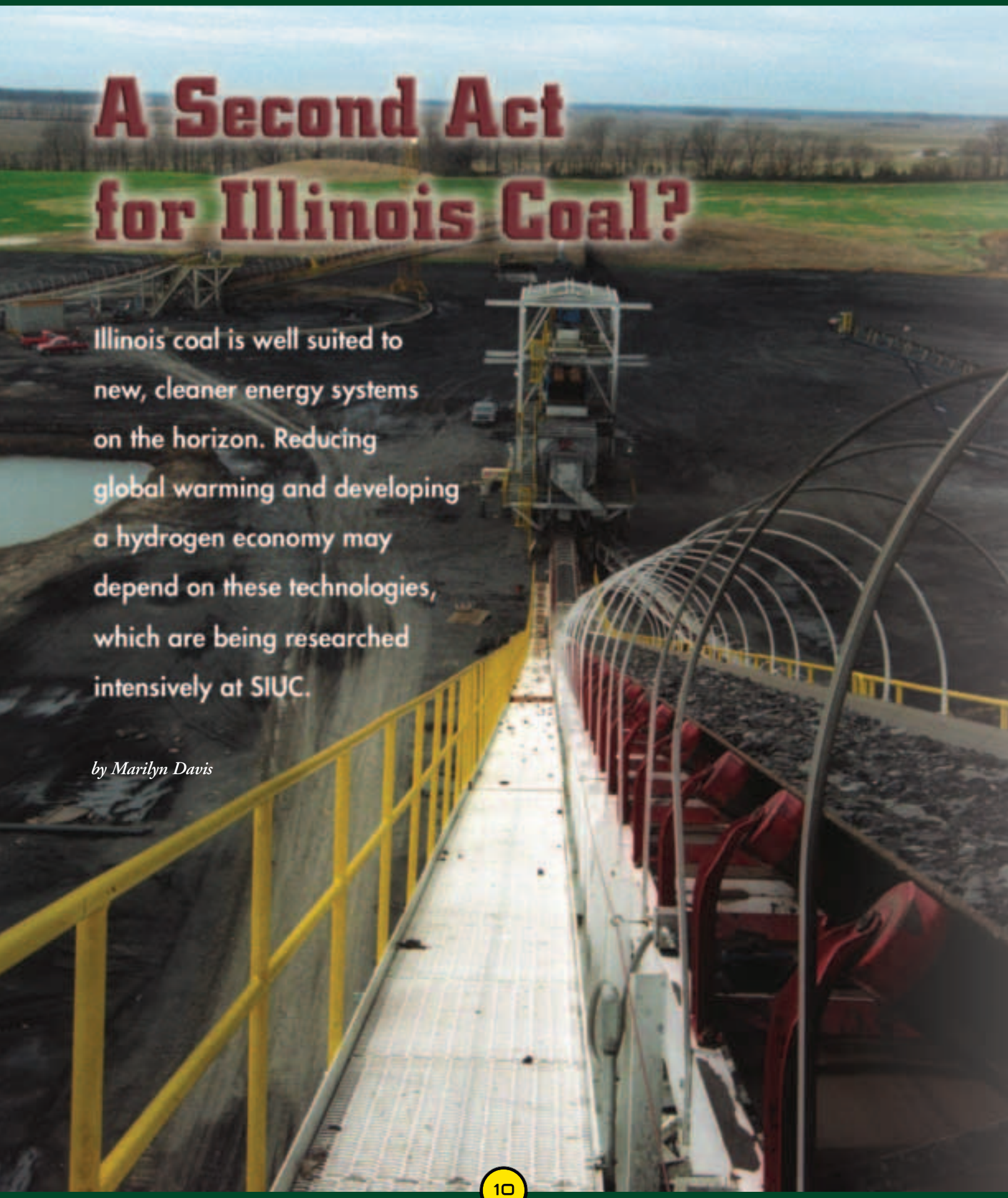
Perchlorate, used by various industries and by the military in solid rocket fuel, poses long-term health risks. Cleanup of sites contaminated with this chemical is difficult for a variety of reasons. As part of an SIUC team that isolated bacteria capable of breaking down perchlorate even in oxygen-deprived environments such as subsoil, Bender did pioneering work by showing how these bacteria function at the genetic level.

She identified and sequenced the genes that trigger production of the enzyme that breaks down perchlorate, as well as several other genes that seem to play supporting roles in the process. She also developed a molecular technique to rapidly detect whether any species of perchlorate-degrading bacteria are present at a given site. That information will help determine site suitability for bioremediation. A patent application has been filed on the technology, and a license was recently granted to BioInsite Inc. for its commercialization.

• **Hilla Medalia,** a documentary filmmaker whose work was showcased in the Spring 2004 issue of *Perspectives,* won the SIU Alumni Association's 2004 Outstanding Thesis Award for her film "Daughters of Abraham." Shot on location in Jerusalem and the West Bank, the documentary explores the lives of two teenage girls: a Palestinian who became a suicide bomber and one of her Israeli victims. "Daughters of Abraham" won a 2004 Angelus Award and was shown at the 2005 Sundance Film Festival.

• **David Rush,** a theater professor, was one of only 10 playwrights nationwide to have a staged reading of one of his works at the 2005 Orlando Shakespeare UCF Festival of New Works. And the work of both costume designer **Kathryn Wagner** and scenic designer **Ronald Naversen** (below), also theater faculty, was featured at World Stage Design 2005, showcasing sets, costumes, lighting, and sound design.

• Four SIUC faculty and staff have won coveted 2005 Illinois Artists Fellowships from the Illinois Arts Council. The $7,000 awards went to poet **David Bond,** music composers **Eric Mandat** and **Frank Stemper,** and performance artist **Christopher Wildrick.**



A Second Act for Illinois Coal?

Illinois coal is well suited to new, cleaner energy systems on the horizon. Reducing global warming and developing a hydrogen economy may depend on these technologies, which are being researched intensively at SIUC.

by Marilyn Davis

Solar power, wind power, biomass power, hydrogen— all have the potential to reduce our dependence on foreign oil. But any significant reduction in the near term, energy experts seem to agree, will depend on an old standby: coal.

"The general consensus at the national level is that we're going to be using coal for the next 30 to 50 years, and probably until the end of the 21st century," says Paul Chugh, professor of mining and mineral resources engineering at SIUC.

That is even more true for rapidly industrializing Third World nations than for the United States. Coal is significantly less expensive than natural gas or oil. It is energy-rich, producing a lot of power for its volume. And although it is a nonrenewable resource, the United States, and the world, have abundant, well-distributed reserves of it—enough to fuel us through the decades it will take to make renewable energy systems economical enough to be widely adopted.

"The only way for the foreseeable future to keep electricity easily affordable is to burn coal," says Satya Harpalani, professor and chair of mining and mineral resources engineering. "The question is how to do that in an environmentally sound way."

Coal gasification and associated technologies may be the key in moving toward a hydrogen-based economy while reducing emissions of carbon dioxide.

The good news, environmentally, is that the United States and other industrialized nations are already starting to move toward using coal in a different way than coal-burning power plants do now. The future, many experts believe, lies in new twists on an old idea: gasification.

Coal gasification and associated technologies may be the key in moving toward a hydrogen-based economy while reducing emissions of carbon dioxide, one of the so-called "greenhouse gases" that contribute to global warming. And with gasification, the Achilles' heel of Illinois coal—its high sulfur content—is no longer a problem.

"Gasification is very attractive for Illinois coal because the high sulfur content is not a disincentive; it is actually a useful byproduct," says John Mead, director of SIUC's Coal Research Center.

"To increase use of Illinois coal, the challenge is to identify new technologies. Sulfur dioxide control technologies are in limited use in Illinois, and so it's not a matter of providing incremental improvements in scrubbers, say. That's not going to radically increase the use of Illinois coal.

"Commercializing gasification is going to."

A New Day for Gasification

In the early to mid-1900s, many U.S. cities and towns had their own coal gasification plant. Coal was heated in the presence of steam and a carefully controlled amount of air to produce a moderate-Btu gas that could be burned for heat and light. This so-called water gas was used in residences, businesses, and street lamps. The process produced a lot of waste and pollution, however. More efficient gasification processes were developed in the 1940s; Germany, for example, used gasification to produce gasoline and other liquid fuels during World War II. But the technology gradually gave way in the 1950s and 1960s to the use of natural gas, which was then cheaper than coal.

◂ **Coal is carried up into a state-of-the-art cleaning plant at the new Willow Lake Mine complex near Harrisburg, Ill.** ***Photo by Jeff Garner.***

In recent years the concept of coal gasification has been revived and gasification technology has been improved. Today's gasifiers use high-temperature, high-pressure vessels and oxygen instead of air to produce high-quality *syngas* (primarily hydrogen and carbon monoxide), which is burned in gas turbines to generate electricity.

Several pilot coal gasification plants are now operating in the United States and other countries, producing both electricity (from syngas) and diesel fuel. The U.S. Department of Energy (DOE) and energy companies are funding research to extend the benefits of gasification, as is SIUC (see sidebar p. 17). These benefits are threefold: efficiency, versatility, and pollution control.

In conventional power plants, coal is burned in order to heat water to drive steam turbine-generators. Only about 30 percent of the coal's energy value actually winds up producing electricity; the rest is waste heat. By using what's called a combined cycle to produce electricity, gasification plants can ratchet efficiency up to 50 percent or more. After syngas is burned, the waste heat from the turbines can itself be used to drive conventional steam turbines, generating additional electricity. In industry jargon, such plants are called IGCC systems, which stands for "integrated gasification combined-cycle."

Gearing Up for the Hydrogen Economy

Gasification can be used for much more than making electricity, however.

"Gasification is a pretty nice process—whatever you need, you can make," says Tomasz Wiltowski, an associate professor of mechanical engineering and energy processes who does research in this area. "And it's more environmentally friendly. Gasification is coming back with new materials and new approaches."

"The real advantage of gasification is that it allows an engineer to design a system where all of the output products can be processed and used," Mead explains. Besides syngas, those products can include methane (natural gas), liquid fuels such as diesel fuel and methanol, chemical feedstocks, and last but not least, hydrogen.

DOE will soon choose a site for a 275-megawatt, near-zero-emissions, IGCC pilot plant that will gasify coal to produce both electricity and surplus hydrogen for uses such as fuel cells. Illinois and a number of other states are lobbying for the $1 billion project, dubbed FutureGen. But wherever it is sited, it will serve as a major impetus for new clean-coal technologies.

Many hopes have been pinned on hydrogen as the transportation fuel of the future. Hydrogen is a clean fuel: when it is burned, it produces only water as a byproduct. But how do you get large quantities of hydrogen to begin with?

You can make it from methane, or by using electricity to split water molecules apart. Both are expensive options, however. Producing hydrogen by gasifying coal may be the best bet, and it can be done cleanly.

COAL BY THE NUMBERS

Percentage of U.S. electric power generated from coal: 51

Percentage of Illinois electric power generated from coal: 46
(almost all the rest comes from nuclear power)

Amount of coal used each day by Americans in the form of electricity:
20 pounds apiece

Amount of electricity supplied by a pound of coal:
enough to light ten 100-watt bulbs for about an hour

U.S. cost in 1999, on a dollars-per-million-Btu basis, for
—natural gas: $2.59 **—petroleum:** $2.56 **—coal:** $1.22

Estimated recoverable coal reserves
—worldwide: 1.1 trillion tons
—in the United States: 268 billion tons
—in Illinois: at least 30 billion tons; possibly up to 80 billion

Percentage of Illinois underlain by coal: 65 (37,000 square miles)

Total U.S. coal production in 2003: 1.1 billion tons
Percentage mined west of the Mississippi: 56

Coal production in Illinois in 1990: 61.7 million tons **in 2003:** 31.1 million tons

Number of Illinois coal miners in 1990: 10,129 **in 2003:** 3,534

Rank of Illinois among coal-producing states in 1995: #6 **in 2003:** #9

Sources: DOE Energy Information Administration; Illinois Dept. of Natural Resources, Office of Mines and Minerals; National Coal Association; "Illinois Coal Fact Sheet," Illinois Dept. of Commerce and Economic Opportunity; Paul Chugh, SIUC Dept. of Mineral and Mining Resources Engineering.

A 250-megawatt IGCC power plant near Lakeland, Fla., constructed as part of the U.S. Department of Energy's Clean Coal Technology Program. *DOE photo.*

A Slice of the Prehistoric Garden

Even the finest coal starts out dirty, a hodgepodge of organic material and inert minerals.

"Coal is truly a slice of garden back in Pennsylvanian times," says Mead. "It's inherently complex. It's a monster molecule incorporating carbon, hydrogen, oxygen, sulfur, chlorine, and other elements—plus there's mineral matter that is physically bound up with coal as it forms, such as pyrite and silica.

"No matter how coal is processed, there are trace solids as byproducts. But there's a different set of technologies today, and environmental control is at the center of the process."

For years SIUC and other universities have worked with government and industry on improved coal-cleaning methods, combustion systems, and smokestack equipment to reduce sulfur and other pollutants emitted from coal-burning power plants—emissions that cause acid rain and smog.

But many U.S. power plants have chosen to burn low-sulfur western coal to meet Clean Air standards rather than invest in clean-coal technology. That's the case even though they have to burn 25 to 30 percent more western coal to get energy production equivalent to that of eastern coal.

Consequently, some eastern mines have closed while mines in western states have opened. Illinois coal production has dropped almost 50 percent since 1990. In 1999, for the first time, more coal was mined west of the Mississippi than east of it.

Gasification levels the playing field for high-sulfur coal.

"It produces very concentrated gas, liquid, and solid streams that are much easier to handle," Mead says. Instead of being drawbacks, pollutants can be separated out and sold to companies as chemical feedstocks. "Gas cleanup systems developed years ago to clean up natural gas can capture nearly 100 percent of the sulfur," Mead explains, "and elemental sulfur can be used for a lot of things. Gasification also is the best means of chemically capturing trace elements such as mercury and selenium."

Types of coal differ significantly from one geographical region to another, which can slow the adoption of new technology by the coal industry. Fortunately, Illinois coal is highly suitable for gasification—better, actually, than western coal.

"It has some advantages because of its chemical composition, energy content, and moisture content," Mead says. "All of the major new gasification technologies worldwide have been designed and evaluated with coal types that include those in Illinois." In fact, Illinois no. 6 coal, a standard grade often used as a reference, is one of the most-researched types of coal in the world.

One thorny problem remains: carbon dioxide. But gasification offers a way to deal with that, too.

Just as climate change is a global concern, carbon dioxide emissions are a global—and growing—problem. Humans produce 25 billion tons of CO_2 every year, mostly from burning fossil fuels in power plants, automobiles, factories, and homes. CO_2 makes up 82 percent of the greenhouse gas "load" in the atmosphere and is considered responsible for much of the global temperature rise of 1°F over the past century. Warming is expected to accelerate over the next few decades.

"Countries that burn a lot of fossil fuels, like China, India, Ukraine, and Poland, have growing economies; they're very energy-hungry," Harpalani says. "They'll continue to burn coal because it's available and cheap."

In 2003 the European Commission estimated that without corrective measures, CO_2 emissions will increase another 50 percent by 2020. Government, environmentalists, and even the energy industry have arrived at the consensus that controlling global warming, and thus putting the brakes on climate change, will require controlling those emissions.

Micro-Scale Power: Recycling "Waste" as Fuel

Gasification, probably the wave of the future for big coal-using power plants, can play other roles as well. Bradley Paul, an associate professor of mining and mineral resources engineering, has been working closely with a new Illinois company called Coaltec Energy USA to optimize and commercialize modular gasifiers for energy use by factories, mines, ethanol plants, and communities.

These small, simple-to-operate gasifiers have two modules. The first gasifies the fuel, and a second burns the gas for heat. If you want to generate electricity with the system, it's a simple matter to add an off-the-shelf heat recovery boiler and turbine.

Modular gasifiers are nothing if not versatile. They can use a whole range of carbon-based feedstocks, gasified separately or with coal, that are typically treated as waste, not fuel. Many of these feedstocks are biomass in some form or another.

Most modular gasifiers in the United States are being used to gasify wood waste, for example. But Paul has chosen to focus on "fuels that other gasification enterprises have steered clear of or ignored," he says.

"They're usually high in moisture or high in ash [unburnable mineral content], and they're found all over. You wouldn't want to transport them very far—you'd be spending more on transportation than they're worth as fuel. To be able to use them economically, you've got to be able to use them for something nearby." Hence the idea of microgeneration: generating heat or electricity for local users.

For example, from 5 to 10 percent of Illinois coal ends up as waste fines at preparation plants, which clean the coal for burning. These tiny particles, below recovery size, are removed from the plant's water stream so the water can be reused. The damp fines are typically disposed of in slurry ponds. "Most of our power plants simply aren't designed to handle that kind of moisture," Paul says.

But modular gasifiers are a different story.

"Suppose a coal mine fed the fines back into a small modular gasification plant to run the mine," says Paul. "We've done studies showing that, for most mines, 70 percent of the energy from that modular plant would fill all of the mine's electrical needs. So the mines are literally throwing away enough energy to run the entire operation, and the 30 percent left over could be sold to communities in the area."

A couple of research grants Paul had in the 1990s brought together the industry partners who later formed Coaltec Energy, which began operation in 2000. (Paul has a small ownership interest and serves on the company's board of directors.) Funding from the Illinois Clean Coal Review Board (see sidebar p. 17) enabled Coaltec to build a commercial-scale gasifier system for testing and demonstration at the Illinois Coal Development Park in Carterville, which is co-administered by SIUC and the state.

Besides coal fines, Paul has modified the gasifier system to work with corn stubble and with ethanol mash, the partially decomposed grain left over from ethanol manufacture. Other fuels could include other crop residues, poultry litter, and even manure.

Air emissions data from the system—measuring nitrogen oxides, carbon monoxide, sulfur dioxide, and particulate matter—have been excellent with both coal and biomass fuels, Paul says. The first test the team ran was with extremely-high-sulfur coal fines from a processing plant. "I kept asking them to run the test over again," he says, "because the sulfur dioxide was coming in lower than sulfur emissions at scrubbed power plants." What he discovered was that the ash in the fuel acts to "grab" the sulfur during gasification, binding most of it up in solid form.

This technology "is not going to replace power plants," says Paul, "but there are niche markets. We can reduce waste volumes considerably"—and get some pretty clean power in return.

Coaltec Energy's test gasifier at the Illinois Coal Development Park. ***Photo courtesy Coal Research Center.***

About one-third of the United States' emitted CO_2 comes from coal-burning power plants, and removing those emissions at the stack would be very expensive. Because today's coal gasification plants are more efficient than coal-burning plants, they emit less carbon dioxide per ton of coal used, which is a plus. But DOE hopes to go much farther.

DOE's plan is for FutureGen to separate out CO_2 at the gasification stage and then *sequester* it—store it underground to keep it out of the atmosphere. And if pure hydrogen is burned for power, the only byproduct is water.

"DOE is trying to implement clean-coal technologies such as IGCC so we can meet air quality standards of the future, not just today," says Paul Chugh. "And that has long-term implications worldwide, because it could open markets in other countries for our technologies."

Breaking Up Is Hard To Do

Making the FutureGen concept commercially viable will require new and improved technologies. To bring costs down, DOE is funding research to find better, cheaper ways to gasify coal and to separate and sequester the CO_2.

An SIUC research team led by Wiltowski has been working to find more-efficient separation technologies. With funding from the Illinois Clean Coal Institute (ICCI) and from DOE through the General Electric Energy and Environmental Research Corporation, Wiltowski has been testing two designs on a proof-of-concept scale. One separates out CO_2 after gasification; the other integrates gasification and separation in a single chamber. Both designs rely on a sequence of two chemical reactions.

Here's how it works, in a nutshell. In a reaction chamber, syngas and steam are passed through a bed of metal oxide particles. The carbon monoxide in the gas mixture grabs oxygen atoms from these particles, changing into CO_2. The gas then flows through a bed of limestone or other calcium-oxide material, where a second reaction takes place: the CO_2 combines with the calcium oxide, creating calcium carbonate.

Meanwhile, the hydrogen in the syngas reacts with these solids scarcely at all. With all of the carbon now bound up in solid form, the hydrogen flows as a virtually pure stream out of the reaction chamber.

Once the chamber is emptied of hydrogen, air is released into it to perform a neat recycling trick. Oxygen from the air resupplies the metal particles with oxygen atoms, regenerating them for another separation cycle. Oxygen from the air also converts the calcium carbonate back into calcium oxide and CO_2. The CO_2 is allowed to flow out of the chamber, and the whole set-up is ready for another batch of syngas.

To keep costs as low as possible, Wiltowski is modifying the metal and calcium oxide particles so that they can be reused for up to 100 separation/regeneration cycles without having to be replaced. In addition, his separation technology works at relatively low temperatures, industrially speaking.

To increase efficiency even more, he has designed a two-chamber system in which each chamber alternates in separating syngas and regenerating the oxide materials. By switching cycles between the two chambers, there's no down time—hydrogen and carbon dioxide are being produced by the system continuously.

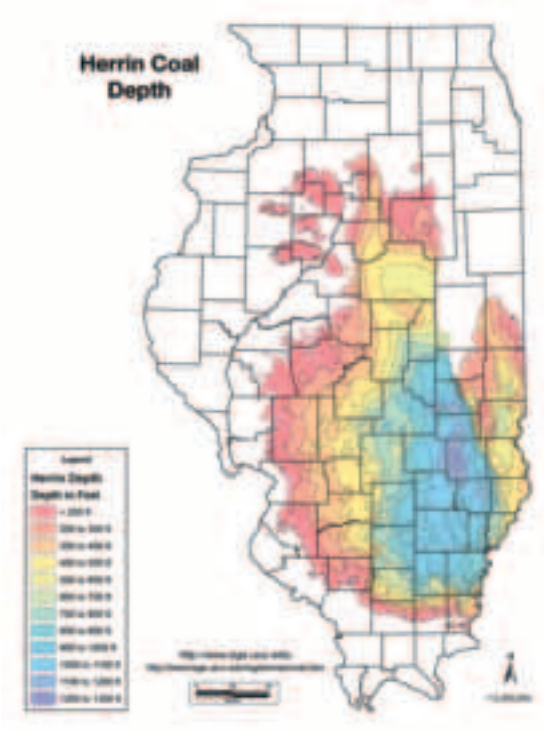
Wiltowski's design has been tested on a small scale, and SIUC has filed patent applications on the design and on the chemical modifications to the oxide materials. Larger pilot testing and industrial demonstration of the system would take a lot more time and much more funding, Mead explains. But this concept, which he calls a "radical project," could pay off.

As he points out, General Electric, the industry partner in this research, recently bought the leading coal gasifier design from Texaco. "They're positioning themselves to be a huge part of coal-based energy systems," he says. "The ultimate effect of our research could be significant."

▲ **Tomasz Wiltowski (left) looks on as graduate student Lubor Stonawski makes adjustments to a pilot-scale experimental gasification system that can separate carbon dioxide from hydrogen.**

FutureGen, which DOE plans to have up and running in 10 years, will almost certainly use an existing, industry-tested gasifier with a separation unit added to it. Wiltowski's scheme could work in such a scenario. His work to integrate gasification and separation processes in a single reaction chamber also could bear fruit, but in the longer term, since it would take much longer for industry to test and adopt an entirely new gasification design.

At the Illinois Coal Development Park in Carterville, which SIUC co-administers, Wiltowski maintains several small-scale gasifiers, ranging from 6 inches to 6 feet high, in order to test new ideas quickly. "Most of the engineering problems you encounter [in scale-up] are in scaling from small to medium sizes, not medium to industrial sizes," he notes. The experimental set-up "enhances our capability to test new gasification concepts in initial pilot tests and then interest industry partners," Mead says.



▲ **Illinois State Geological Survey draft map showing the Herrin coal seam, which is being studied for its potential for methane production and CO_2 sequestration. Coal beds at least 900 feet deep are more likely candidates for sequestration.**

Putting Carbon Back Underground

Sequestration, a key part of the FutureGen project, means storing carbon dioxide underground—in oil or gas reservoirs, coal beds, very deep saltwater aquifers, or even under the ocean floor—so that it is stable and can't return to the atmosphere.

That purpose is new, but the practice of pumping carbon dioxide underground has been going on for decades. Energy companies buy CO_2 extracted from underground sources (in other words, not byproduct CO_2) and pump it into oil reservoirs to recover more oil. "You need some pressure for a fluid to flow," Harpalani explains, "and as you take oil out of the reservoir the pressure drops. Carbon dioxide provides the driving force to push the oil out."

Several sequestration pilot projects are already ongoing or planned in various other countries, according to *Science* magazine. The largest is by Norwegian oil company Statoil, which recovers natural gas from oil fields beneath the North Sea. Statoil has been separating CO_2 from the gas and pumping about 1 million tons of it per year into rock strata more than 1,500 feet below the ocean floor. The process costs about $15 per ton of CO_2 but saves the company a $55-per-ton tax that Norway imposes on CO_2 emissions to help reduce global warming.

Scientists and the government want to make certain that sequestered CO_2 will stay put. If it should filter up into freshwater aquifers, it could acidify groundwater sources used for drinking. And even though CO_2 isn't toxic, sudden releases of large amounts of it can be literally suffocating in some conditions. For that reason, sequestration can be done only in geologically stable areas and relatively deep rock strata, reservoirs, or aquifers. Illinois State Geological Survey (ISGS) research indicates that some sites in the state, including deep coal beds in southeastern Illinois (see map), may be suitable.

Without government incentives, U.S. companies need another economic reason to invest in sequestration. Harpalani's research will help geologists determine if carbon dioxide can be sequestered in Illinois coal beds while simultaneously producing methane. His work is being funded by the ICCI, the National Science Foundation, and DOE through the ISGS.

Methane production is a fairly new idea for Illinois—scarcely any methane is produced in the state—and Harpalani's research indicates that it is a promising one.

"Other states have been getting methane out of coal for a long time," he says. "But in Illinois, no systematic study had been done" until a 2001 ISGS study indicating that significant amounts of methane exist in parts of the Illinois Basin (the coalfields that underlie some three-quarters of the state, plus much of southwestern Indiana and part of western Kentucky).

"Some of the sweet spots are in Southern Illinois," says Harpalani, who notes that some Illinois mines even have to stop production periodically to wait for excessive amounts of gas in the mine to vent.

Several years ago, as a faculty member at the University of Arizona, Harpalani worked with the only CO_2 sequestration pilot study to date in the United States. The three-year project recovered additional methane from methane-producing coalfields in New Mexico.

"Normally if you're getting methane out of coal beds, you get only about 50 percent of it," Harpalani says. The pressure is too low at that point to recover the remainder.

For the pilot project, the company involved converted some of its extraction wells into injection wells. "Over three years they got the extra methane out, and the CO_2 they pumped in, which was billions of cubic feet, never came back out," Harpalani says. "That suggests it's there permanently."

Data from the New Mexico study won't apply to Illinois because the coal type and coal depth are different here. So Harpalani and his graduate students are doing lab experiments with samples of Illinois coal under realistic field conditions of pressure and temperature. Their findings will help the ISGS choose sites and set parameters for field studies.

"My research is characterizing flow behavior and storage properties," says Harpalani. "How easily does carbon dioxide flow into the coal, and how long before flow becomes more difficult? Will it displace methane, and how much methane can we get out? What are the optimum injection pressure and rate of injection? Will the CO_2 stay there permanently? And in the end, how much CO_2 can be sequestered in a particular area?"

Flowing and Sticking

Gas molecules containing carbon atoms will cling to the pores in coal, a phenomenon called adsorption. Methane adsorbs well to coal, which is why you find it in coal beds to begin with. But carbon dioxide molecules adsorbs even better. If CO_2 is introduced into a coal sample, 98 percent of its molecules will adhere to the coal's pores.

Harpalani has found that Illinois coal has two to three times as much affinity for carbon dioxide as for methane. That differential is enough to enable injected carbon dioxide to displace methane, he says. CO_2 in, methane out. And coal's affinity for carbon dioxide also means that sequestered CO_2 should be stable. "The capacity of coal to hold onto CO_2 is huge," he says.

Harpalani's lab studies also have found that the permeability of Illinois coal—the ease with which gas will flow through it—is sufficient for methane production and CO_2 sequestration. The trick is finding a balance.

"Coal has fractures. If you put in CO_2, the coal matrix swells and decreases the size of those fractures," Harpalani explains. Experiments in his lab show that low-pressure injection is the way to go with Illinois coal beds. "You don't want to [close up] the passage, so you keep the pressure low," he says. In addition, he says, "We want to put in less CO_2 than what the coal can retain, for a safety margin."

Using their lab data and ISGS data on gas content in portions of the Illinois Basin, Harpalani's team ran simulations to determine the potential for methane production with and without carbon dioxide injection. Without CO_2, they found, about 40 percent of the methane at a given site could be recovered over about an eight-year period. With CO_2 injection, 70 percent could be recovered. And the amount of CO_2 that could be sequestered would be about three times the amount of methane recovered.

Pilot-scale field experiments will be needed to follow up the laboratory results and investigate safety. "Laboratory research alone won't establish safety," Harpalani says. "It establishes trends—parameters."

More work also still needs to be done on the properties of Illinois coal. Harpalani's research has now expanded to, of all things, having C-T scans done of Illinois coal samples to see the size, number, and spacing of fractures.

Putting Technology into Practice

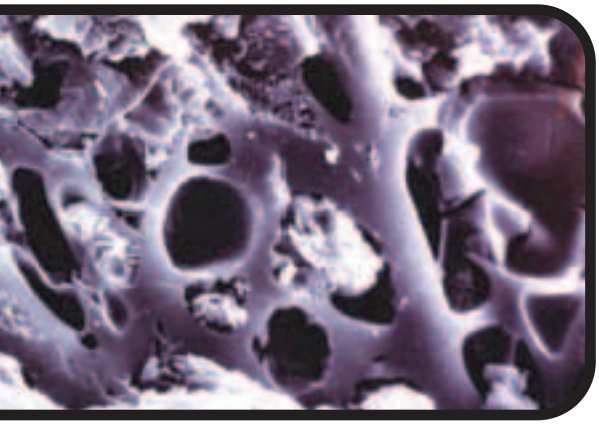
In 2000, Commonwealth Edison Co., a Chicago-based electric utility, made a $25 million grant to SIUC to support clean-coal projects. The university established the Clean Coal Review Board (CCRB) to leverage additional funding and support innovative industry projects with the grant. The goal: getting the best cutting-edge clean-coal technologies in use in Illinois.

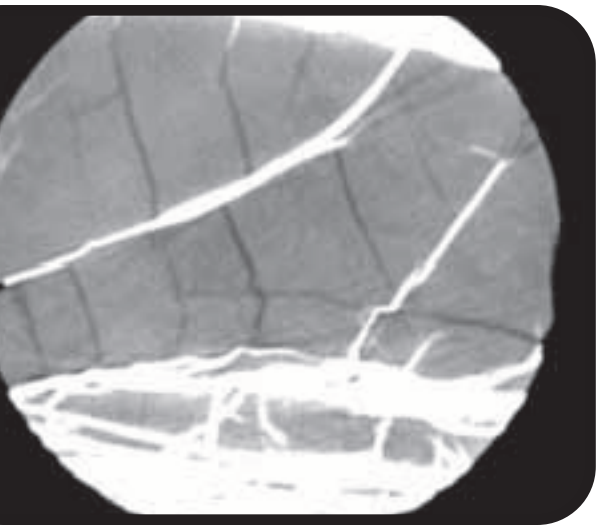
The CCRB bridges university research and industry practice. "We're involved in co-funding some stages of project feasibility and project engineering that are critical to commercialization," says SIUC Coal Research Center director John Mead.

The CCRB has to date invested about $13 million in several gasification projects around the state that will use Illinois coal. Companies are:

- Building a gasification facility adjacent to a new coal mine in Williamson County, for production of synthetic natural gas and syngas.
- Converting a fertilizer production plant in East Dubuque from natural gas to coal as a feedstock to produce both fertilizer and ultra-clean diesel fuel.
- Conducting a feasibility analysis for a new gasification power plant near Taylorville that would also produce chemicals such as sulfur and liquid fuels such as methanol.
- Developing a large-scale gasification plant in Fayette County to produce liquid fuels from coal.
- Demonstrating a small power-generating unit at SIUC's Illinois Coal Development Park that can gasify various carbon-based fuels, including "waste" coal and agricultural wastes (see sidebar p. 14).

Other CCRB grants are funding advanced coal-combustion systems to reduce smokestack emissions, as well as advanced coal-mining and coal-processing techniques to recover more clean, usable coal.





From top: A core sample from the Herrin coal seam (the yellow is probably sulfur); an electron micrograph reveals the pores in coal; a C-T scan of a coal sample shows numerous fractures. *Photos courtesy Satya Harpalani. Bottom photo courtesy TerraTek.*

"We still don't know what kind of fracture characteristics Illinois coal has," he says. Until now, he has had only electron micrographs to study. These reveal a lot about coal structure, but only for one thin slice of coal at a time. A sequence of C-T scans will give Harpalani a 3-D picture.

A new ICCI grant will allow him to test an even more novel idea, one that—if it works—could handle carbon dioxide emissions from conventional coal-burning plants too. Coal combustion flue gas is only partly CO_2; most of it is nitrogen. Separating the CO_2 from the nitrogen in order to sequester it would be very energy-intensive.

Harpalani's idea is to use coal beds as a cheaper, natural filter instead. Nitrogen has little affinity for coal. If flue gas were injected, would the CO_2 adsorb to the coal while allowing the nitrogen to simply pass through? Harpalani plans to find out.

At the Mouth

Sequestration will inevitably bump up the cost of electricity, although DOE hopes to hold FutureGen to only a 10 percent increase over a non-sequestered system. But improving mining productivity can help make both IGCC systems and sequestration more feasible economically. Mining engineering professor Chugh, for example, is overseeing several projects with the overall goal of cutting the cost of a ton of coal by 20 percent or more.

The Midwest, Chugh's data indicate, will see about a 10 percent increase in demand for power over the next five years. Chugh worked as a DOE intern in summer 2004 to study the potential for meeting that demand with gasification technology. The chief roadblock for companies, he says, is "the capital costs requirement and the uncertainty of economic feasibility," given that a 1,000-megawatt IGCC plant would cost at least $1.5 billion to build.

Chugh's solution is to offset costs by using a mine-mouth approach. That means siting coal preparation plants and power plants adjacent to mines to avoid having to ship the coal. (Shipping coal by rail costs about 4 cents per ton per mile, which adds up fast.) By using mine-mouth facilities, IGCC is economically feasible in the Midwest, Chugh's analyses show. "It helps a bundle," he says. "It helps enough."

The mine-mouth concept also can come into play with new combustion plants using the best pollution-control technologies. Such plants are expensive propositions too. The more that companies can bring down the cost of a ton of coal, the more they can justify the capital outlay for building a state-of-the-art facility.

Chugh and Bane Kroeger, an assistant professor of mining and mineral resources engineering, are using a $250,000 grant from the Illinois Clean Coal Review Board (see sidebar p. 17) to demonstrate the technical and economic feasibility of the mine-mouth approach at a pilot-scale coal industrial park. Three sites in central Illinois are being considered. Because building a small power plant for the demonstration isn't an economical option for industry partners, the park will burn the coal using a modified fluidized bed combustion unit and run an ethanol plant with the resulting steam.

The combustion unit will use limestone to capture sulfur dioxide. Combustion waste and waste from fine coal cleaning will be used for construction in and around the mine. With DOE funding, Chugh and his team have successfully tested support pillars made of this material.

"Every new mine should look at the mine-mouth approach," Chugh says.

"We want zero or near-zero solid waste discharge from the mine, and we want to squeeze every Btu we can out of the coal we're producing."

Waste Not, Want Not

Another way to increase productivity while helping the environment is to reduce the amount of waste material mixed in with the coal coming out of the mine, which can account for up to 35 percent of the yield. Preparation plants remove as much of that extraneous material as possible, but it's an imperfect process.

The problem is that continuous miners, the big machines that bite out the coal at the mine face, don't just hit the coal seam. They also bite into a bit of the rock strata above and below, and that material gets mixed in with the coal. The phenomenon is called "out-of-seam dilution." For safety reasons these machines are controlled remotely, from 20 to 25 feet away, so the operators can't see when the machinery is getting out of the seam.

"We're the only ones in the world who have done a systematic study of out-of-seam dilution and its impact on coal production costs," says Chugh. "We found that it can increase the cost of producing coal by 20 to 25 percent. Most people in the industry don't realize that. Out-of-seam dilution also affects coal quality—it adds big-time to the amount of trace elements in the air."

Chugh worked with Viper Mine, in Elkhart, Ill., to develop a pilot training program to help operators reduce out-of-seam dilution. "We thought from some earlier work we did that we could reduce it by 3 inches," he says. "We've achieved 1 inch, and the rest will require developing a device by which the operator can control the height of the mining head, so he knows if it is starting to contact the roof or the ceiling [i.e., pulling in material from outside the coal seam]. That's the next step, and we're already working on it."

The machinery in underground mines creates a lot of fine coal particles at the mining face that get mixed in with the coarse coal. Another way to reduce waste and increase mining efficiency is to clean, dewater, and use this fine coal (generally defined as less than 1 millimeter in diameter) instead of discarding it. Over the years, SIUC and other researchers have tested and refined various fine-coal cleaning and dewatering technologies for their suitability for Illinois coal. But nearly half of the preparation plants in Illinois have yet to adopt such systems.

In fact, Illinois plants are disposing of about 1 million tons of fine coal in slurry ponds every year, says Manoj Mohanty, an assistant professor of mining and mineral resources engineering. If only half of this "waste" coal were recovered—cleaned and dewatered to make it suitable for burning—the Illinois coal industry could generate an extra $10 million per year. That would enable companies to cut the selling price of Illinois coal and still maintain profits.

The systems used at preparation plants to clean coarse coal of extraneous mineral matter don't work efficiently for fine coal, which must be separated out. Within the fine-coal range, many plants further separate out particles 150 microns or bigger, which can be cleaned using conventional technologies. But coal particles smaller than 150 microns—much finer than the finest sand—can't be handled by most plants and get discarded.

This situation will change, Mohanty hopes, with new technologies he has tested. With funding from the ICCI, he and Bane Kroeger first tested a new type of screening equipment, originally developed in South Africa, at the

From top: Manoj Mohanty (center) and workers at Knight Hawk Coal Co. test a coal separation screen; testing a steel belt filter system for dewatering coal; Mohanty's new flotation cell for improved cleaning of fine coal. ***Photos courtesy Manoj Mohanty.***

Making Combustion Byproducts Pay

No matter how quickly gasification may be adopted for new power plants, coal-burning plants will still be around for years to come. While clean-coal technologies to control polluting emissions cut down greatly on the *atmospheric* waste such plants produce, they inevitably increase the amount of *solid* waste.

For example, smokestack scrubbers to remove sulfur produce tons of scrubber sludge, almost all of which is landfilled. Another major type of coal waste, fly ash, has been used for several decades in concrete, but clean-coal technologies such as fluidized bed combustors produce fly ash with different, little-tested properties, along with heavier bottom ash.

SIUC researchers have been leaders in figuring out ways that companies can turn this waste into useful products instead of paying to dispose of it. Current projects, some of which have been featured in *Perspectives,* include:

- Using fly ash and other combustion waste as grout inside a PVC shell to make **utility transmission poles.** Principal investigator: Paul Chugh, Dept. of Mining and Mineral Resources Engineering.
- Using scrubber sludge to make stain-resistant, nontoxic composite materials such as **paperless structural wallboard, decorative tiles, countertops, and wood substitutes.** Principal investigator: Vivak Malhotra, Dept. of Physics.
- Using FBC bottom ash to replace sand in pre-cast concrete piles and drilled shafts for **deep building foundations.** Principal investigator: Sanjeev Kumar, Dept. of Civil and Environmental Engineering.
- Using scrubber sludge and ash, with small amounts of lime and cement, to make a low-cost construction substitute for concrete pads in **cattle feedlots.** Principal investigator: Paul Chugh.

Supporters of these various projects include the U.S. Department of Energy, the Illinois Clean Coal Institute, the Illinois Department of Commerce and Community Affairs, the Illinois Department of Transportation, and industry partners.

Knight Hawk Coal Company's Creek Paum mine near Ava, Ill. The equipment, called a Pansep Screen, "does an excellent job" separating out that sub-150-micron fraction, Mohanty says. Then, with a second ICCI grant, he added and successfully demonstrated two new pieces of technology at Creek Paum that can process coal this size: a cleaning system developed in Germany, and a dewatering system developed in South Africa.

The first system, called a G-Cell, uses a froth of water bubbles to carry coal particles away from heavier impurities. It also uses centrifugal gravity forces to spin out some of the hardest-to-remove impurities: sulfur-laden pyrite particles. Mohanty was interested in the G-Cell over other possible cleaning technologies because its ability to reduce pyrite is a good choice for high-sulfur Illinois coal. The equipment had been tested on a pilot scale in Europe but hadn't been evaluated yet in the United States.

The dewatering system, called a Steel Belt Filter, combines two conventional dewatering technologies. It first removes some of the water using a vacuum filter. Then, to squeeze out as much of the remaining water as possible, it feeds the concentrated slurry between two steel mesh belts moving in opposite directions.

Mohanty's goal was to optimize these technologies for the types of coal found in Illinois. They're more efficient and economical than current technologies, he says, and thus should be more attractive to Illinois plants. They could be adopted in the near term. What's more, he says, they also could be used to recover fine coal from existing slurry ponds.

With a grant from DOE, Mohanty and his team also recently tested equipment at an earlier stage of development that he designed himself. His invention ultimately could replace two steps in processing fine coal—size separation and cleaning—with one step. It can clean all coal particles below the 1 millimeter threshold with no further separation required.

The invention, called an EG (for enhanced gravity) Float Cell, "is the first of its kind to do that job efficiently," Mohanty says. SIUC, which will file a patent application on the invention, has already found an industry partner to commercialize it.

Keep on Truckin'

Finally, mining productivity also relies on keeping the machinery running. And little things can gum up the works.

Take dust. It's a health hazard for miners, and the government limits the amount of fine dust (the most dangerous kind) to 2 milligrams per cubic meter of mine air. Often, productivity levels must be lowered to keep mines in compliance.

Scrubbers mounted on continuous miners function something like wet vacs, sucking in air and spraying it with water to wet and filter out dust particles. Chugh recently partnered with Joy Mining Machinery to improve scrubber design. With dust under better control, productivity can stay higher, bringing down the cost per ton of coal. One coal company has already ordered new scrubbers based on the SIUC/Joy design.

Chugh and his team are also working with industry to redesign and test two different

haulage systems to improve the efficiency of transporting coal from the mine face. Continuous miners scoop the coal onto a belt that carries it back to haulage cars. When cars are changed out, the machine must stop running for up to a minute. That sounds negligible, but think again.

"Continuous miners produce 16 tons per minute," says Chugh. "If you can gain even 10 minutes of extra productivity over an 8-hour day, that's an extra 160 tons—which is 2 to 3 percent of the mine's output. That's pretty substantial."

One of the haulage systems being redesigned is a modification of what's currently in use; the other is a revival and adaptation of an older design from the 1970s. The goal is achieving near-continuous haulage.

In another project that will increase efficiency, Ohio-based Excel Mining Systems Inc. recently licensed a type of steel roof support invented by Kroeger to replace wooden and other steel props in longwall mining. Kroeger's telescoping props can be installed in less than two minutes by a miner working alone. They also are safer than current steel props, some of which can't bear the weight of the mine roof until workers have finished tightening the bolts. The new props, which will be on the market within the next few months, have an adjustable, telescoping design to fit roofs of varying heights and can support a roof as the prop is being jacked into place.

"We're at the cutting edge of new mining systems development," Chugh says. These new systems can help pave the way to adopt IGCC technology by making coal production more economical, but they also can help existing operations. And many of them reduce pollution and waste.

Companies anticipating tougher air pollution standards that will necessitate scrubbers on all combustion plants—even those burning western coal—are already planning to open several new underground mines in Illinois. Others would like to take a renewed look at Illinois coal, Chugh says.

The saying may be "black as coal," but the future of Illinois coal is looking greener. ✦

▲ **Using a hydraulic lift, Bane Kroeger tests the new type of mine roof prop he designed.**

For more information about the projects featured in this article, contact the relevant researcher: Tomasz Wiltowski, (618) 453-7000, tomek@siu.edu; Paul Chugh, (618) 453-7922, ypchugh1@yahoo.com; Satya Harpalani, (618) 453-7918, satya@engr.siu.edu; Manoj Mohanty, (618) 453-7910, mmohanty@siu.edu; Bradley Paul, (618) 453-7923, paul_b@engr.siu.edu; Bane Kroeger, (618) 453-7919, kroeger@siu.edu. For more information about SIUC's coal research program, contact John Mead, (618) 536-5521, jmead@siu.edu.

Rhythm
IN THE GRAIN

by Marilyn Davis

In common parlance, "wooden" means expressionless. But not in Stewart Wessel's book. Give him the right tools, and he can make wood sing.

An artist and associate professor of architecture at SIUC, Wessel has been exhibiting his wood sculptures nationally since 1999. These works take their inspiration from many things: architectural models, furniture design, religious objects—and music.

Wessel's sculptures, some of which are freestanding and some wall-mounted, have straight, clean lines. They're abstract, intricate, and elegant. Some of them shelter organic-looking shapes within their geometric structure, and many of them consist of series of forms.

"What I enjoy about sets of things is that it's like theme and variations in music," Wessel says. "There's a motif you repeat, but room for improvisation. This idea of sets also goes back to furniture design. Furniture usually exists in repetition: Three cabinets, not one."

If these series seem like ritual objects, that's no accident. "When you repeat similar forms, it gives the piece a ceremonial or even religious feel," Wessel says. He has been influenced by "vernacular churches"—those whose design, especially for icons and appointments such as cabinets, was done by local carpenters and reflects local styles.

Wessel's love of music—classical when he works; jazz and rock at other times—is reflected everywhere in his work in the rhythmic repetition of detail. Some of his pieces even echo the shapes of instruments such as clarinets, flutes, and guitars.

"I really like musical instruments as objects," says Wessel, who plays the drums, piano, and flute. "A set of drums is almost a piece of furniture or a sculpture."

Calling himself a "modernist at heart," he admires 20th-century master architects such as Mies van der Rohe and Eero Saarinen, whose styles emphasized geometry and clean shapes. His work also has been strongly influenced by 20th-century artist Louise Nevelson, whose large sculptures are constructed of many pieces.

Wessel works mostly with American hardwoods—walnut, cherry, pecan, poplar, ash, red cedar. For large, wide, delicate pieces, he turns to birch plywood, often used for architectural models.

"One of the beauties of using wood is the color and the intricacy of the grain," he says. "You look for unique patterns, which are a natural design. Some woods have a cool feel to the hand; some are warmer. With some of the softer woods you can always feel the grain pattern, no matter how you finish it. And some hard woods you can finish to feel like glass."

Wessel's art also can go by the rubric "fine craft," a term he likes for its emphasis on workmanship. "The combination of [artistic] concept and skills development keeps it interesting for me," he says.

The tools of his trade are familiar to any woodworker: table saws for straight pieces, band saws for curves and big pieces, scroll saws for intricate work, planers to smooth surfaces and control thickness, routers to shape edges and cut grooves, plus belt, disk, and spindle sanders.

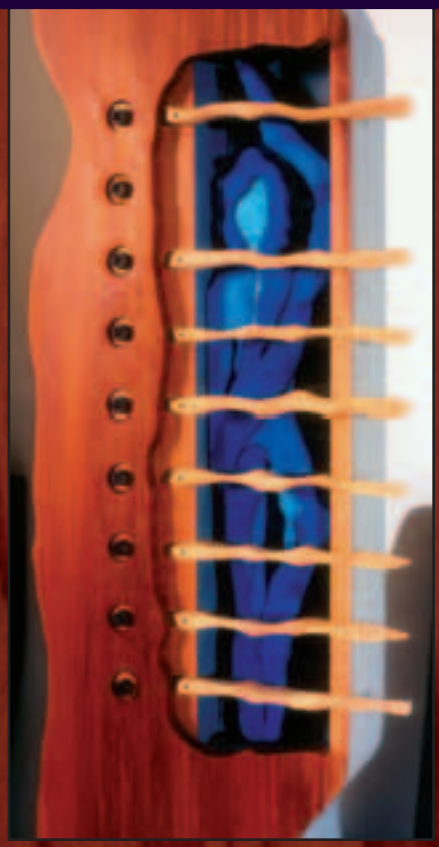
Most of Wessel's sculptures play off a light wood like poplar against a darker wood like walnut or cedar. He uses pegs and glue to assemble the pieces, for both aesthetic and technical reasons. "I don't use any metal fasteners if I can avoid it, because I do a lot of working of the wood after it's put together," he says.

Using acrylics, Wessel sometimes paints components of his sculptures. "I'm starting to use a lot more color in combination with natural wood," he says. One recent piece includes painted panels with incised branching patterns that look like river valleys. That harks back to architecture's

▲ Stewart Wessel.

▲ "Blue Dancers," 2001.

◀ Opposite page: "Red Escape," 2002.



From left: "Tribal Cabinet," 2000; "Wave Trap," 2003; detail from "Blue Trap," 2004.

emphasis on setting, says Wessel, adding, "Nature influences all art."

He's branching out in other ways too. He's begun including copper inlays with etched designs in some of his pieces and hopes to expand his metalworking skills.

Wessel began making things out of wood when he was only five. "My dad was a cabinet builder and a carpenter, and we had a basement full of scraps of wood," he says. "I can remember spending whole days down there, gluing and hammering pieces of wood together. I never really stopped doing that."

For many years after high school he worked for his father, learning to build houses. He earned an education degree from SIUC in 1983, then went to work for a Texas architecture firm, where he also designed a lot of built-in furniture. The concept of a piece was always more important to him than function, however, and he later went to the University of North Texas for his MFA in studio art, focusing on interior design and sculpture.

Over the years his works have "become more and more narrative," he says. He feels uncomfortable talking about what his art means, preferring that viewers find their own stories in it. But some themes are undeniable. For example, his sculptures often include human figures, sometimes caged within the wood, but sometimes breaking free. This motif of entrapment and escape "is part of the human condition," he says.

Wessel's office in Quigley Hall is a work of art in itself. One side is lined with Scandinavian-style tables he made from discarded office doors. Shelves above display brochures and awards from exhibits that have showcased his work. Other shelves hold art books, along with a flute and small sculptures made by his students. At one end of the room is a drum pad; at the other, a set of bongo drums. ("I can play those after five o'clock," Wessel confides. "They banned me from playing them any earlier.")

Wessel teaches furniture design, a beginning design studio, and a seniors' architecture studio. Many of his courses, he says, stress the same concepts, such as rhythm and narrative, that he explores in his art.

"There's a strong relationship between what I make and what I teach," he says.

"What I ask of students is almost exactly what I pursue myself as a creative activity."

Stewart Wessel was named the 2005 Outstanding Scholar for SIUC's College of Applied Sciences and Arts. His sculpture has been exhibited in 19 states and has received a number of awards. More of his work can be seen at ***swessel.myexpose.com.***

A River Runs Through It

"U.S. Geological Survey topographic maps and similar maps published in other countries are the most fundamental sources of geographic information; many other types of maps are based on these. Yet they show only one-third of all the mileage of stream channels that occur on the ground. Reuben's method maps stream channels with over 90 percent accuracy using only Digital Elevation Models (DEMs)—a data source that is now available for the entire globe. That means that Reuben's method can be used to accurately map the majority of stream channels in the world in a straightforward automated fashion."

—Christopher Lant, professor of geography and environmental resources

Ed.—Resource managers and planners need the best possible picture of our world. The image above at left depicts a stream system in the Flint Hills region of east-central Kansas as represented on a USGS map—but in fact this shows only about 35 percent of the "stream miles" in the system. Many small tributaries don't even appear on the map. The image at right is a much more complete map generated by SIUC student Reuben Heine.

The September 2004 issue of the *Annals of the Association of American Geographers* published an article by Heine and Lant describing an improved, automated method, based on Heine's master's thesis research, to map streams and their tributaries. Heine, now a doctoral student in the environmental resources and policy program at SIUC, developed a mathematical method using logistic regression that allows stream maps to be generated rapidly by extrapolating from satellite data on land elevation. Ground truthing—checking the extent to which those maps match reality—has confirmed the accuracy of the method. Heine is now working on better methods to identify which streams are perennial and which are ephemeral (carrying water only part of the year). He is a co-recipient of SIUC's first (2005) Outstanding Graduate Student Researcher award.

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